EMISSIONS STANDARDS

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THE CLEAN AIR ACT AND NEW SOURCE PERFORMANCE STANDARDS

The Clean Air Act (CAA) of 1963 and its 1970 amendments form the basis for air pollution control legislation in the United States, authorising the development of federal and state regulations to limit emissions from industrial sources and transportation. The CAA defines National Ambient Air Quality Standards (NAAQS) for ambient levels of a range of pollutants (including SO_2, NOx, and particulate matter), as well as emissions limits known as New Source Performance Standards (NSPS) for new industrial sources of pollutants, such as coal plants.

CLEAN AIR ACT AMENDMENT OF 1977

Following a 1977 revision of the CAA, further regulation of new sources was introduced based on whether the NAAQS were met within their administrative region. For 'attainment areas', a ruling for Prevention of Significant Deterioration (PSD) of the air quality requires that the best available control technology (BACT) be implemented for new sources, while those in 'non-attainment areas' are subject to the more stringent 'lowest achievable emissions rate' (LAER). These are case-by-case assessments which essentially use the NSPS as baseline emissions limits, but usually require much higher levels of abatement. A BACT assessment will determine the maximum degree of control that can be achieved by a source within reasonable energetic and economic bounds, whether by abatement technology or process changes such as fuel switching. This is based on analysis of emissions already achieved by existing plants within the same category (for example, pulverised coal plant). For LAER, a strict limit is imposed without consideration to the economic or energetic penalty to the plant, and emissions must often be offset against other emissions reductions in the region. These assessments, known collectively as New Source Review (NSR), are generally conducted at the state level as part of State Implementation Plans (SIP) for achieving and maintaining the NAAQS. These plans may also include limits on plants built before 1971 which are exempt from the NSPS.

The NSPS have applied to all coal plants constructed, reconstructed, or significantly modified since September 1971, and have become progressively more stringent since their first incarnation, with the most recent revision applying to plants constructed since May 2011. Significantly, since 1978 the standards have required a percentage reduction of SO_2 emissions from unabated levels in addition to an absolute limit. Although violations of NSPS are distinct from NSR/PSD violations, the Environmental Protection Agency (EPA) generally concentrates on enforcing the stricter, latter regulation.

NSPS for utility coal plants

Standards of performance for electric utility steam generating units

Year of construction/ modification	SO_2	NOx	Particulate matter
1971 – 1978	520 ng/J heat input	300 ng/J heat input	43 ng/J heat input
Sep 1978 – 1997	520 ng/J heat input and 90% reduction (or 70% reduction where <260 ng/J); 180 ng/J gross output; 65 ng/J heat input	subbituminous: 210 ng/J heat input; other coal types*: 260 ng/J heat input	13 ng/J heat input
1978 – Mar 2005		new plant: 200 ng/J gross output; reconstructed: 65 ng/J heat input	
Commenced construction: Mar 2005 – May 2011	180 ng/J gross output; 95% reduction	130 ng/J gross output	18 ng/J gross output; 6.4 ng/J heat input or: 13 ng/J input and 99.9% reduction
Commenced reconstruction: Mar 2005 – May 2011	180 ng/J gross output; 65 ng/J heat input; 95% reduction	130 ng/J gross output; 47 ng/J heat input	
Modified: Mar 2005 – May 2011	180 ng/J gross output; 65 ng/J heat input; 90% reduction	180 ng/J gross output; 65 ng/J heat input	18 ng/J gross output; 6.4 ng/J heat input or: 13 ng/J input and 99.8% reduction
Construction or reconstruction after: 3 May 2011	130 ng/J gross energy output; 140 ng/J net energy output; 97% reduction	88 ng/J gross output; 95 ng/J net output	11 ng/J gross output; 12 ng/J net output
Modified after: 3 May 2011	180 ng/J gross output; 90% reduction	140 ng/J gross output	18 ng/J gross output; 6.4 ng/J heat input or: 13 ng/J input and 99.8% reduction

* except slag tap furnaces firing more than 25% lignite mined in North Dakota, South Dakota, or Montana (340 ng/J)

Notes:

Applies to utility coal plants over 73 MW heat input (including IGCC from March 2005). All requirements within a category must be met unless alternatives are stated.

SO_2 standard exceptions: Plant using solid-solvent refined coal (520 ng/J and 85% reduction). Plant using 100% anthracite, classified as a resource recovery unit, or in a non-continental area (520 ng/J). Plant firing ≥75% coal refuse and, constructed since March 2005 (180 ng/J gross output, 94% reduction), reconstructed since March 2005 (180 ng/J gross output, 65 ng/J input, 94% reduction), modified since March 2005 (180 ng/J gross output, 65 ng/J input, 90% reduction).

NOx standard exceptions: Plant firing >75% coal refuse is exempt from NOx limits if constructed before 1997, and limits of 110 ng/J gross output and 120 ng/J net output apply if constructed after May 2011. For IGCC constructed 2005–2011, 130 ng/J gross output applies. Plant constructed after May 2011 can chose to meet alternative combined NOx and CO limits of 140 ng/J gross output and 150 ng/J net output.

Particulate matter (PM) standard exceptions: Plant constructed before 2005 and without continuous emissions monitoring can meet an opacity limit of 20% (including 6 min/h of 27%).

Conversion to mg/m^3: For comparison with international emissions standards, a rough conversion of ng/J heat input to mg/m^3 can be performed, although the exact relationship will depend on coal type and other factors. The IEACCC uses a basis of coal with 30 GJ/t heat value, producing 350 m^3/GJ flue gas volume (6% oxygen, dry gas at 0°C and 101.3 kPa), which yields a conversion factor of 2.86.

For conversion of ng/J gross output, this value will be factored by the plant efficiency. For a gross efficiency of 35%, the conversion factor to mg/m^3 becomes equal to 1. Average net efficiency of US coal plants is 33% (HHV).

THE ACID RAIN PROGRAMME

A major amendment to the CAA in 1990 included the Acid Rain Program (ARP) aimed at significantly reducing SO_2 and NOx emissions from existing emitters through a system of cap-and-trade. A first phase of this programme ran from 1995 to 1999 applied to 110 major sources and allocated emissions allowances based on an emission rate of 2.5 lb/MBtu (3.87 kg/MWh) of SO_2 and a plant's average fuel consumption in the base year, aimed at achieving an annual cap of 8.95 Mt/y. A second phase from 2000 expanded the programme to all fossil-fired boilers over 75 MWe and based allowances on 1.2 lb/MBtu (1.86 kg/MWh) SO_2. NOx emissions were limited to 0.45 lb/MBtu (0.70 kg/MWh) for tangentially fired coal boilers, and 0.46 lb/MBtu (0.71 kg/MWh) for wall-fired boilers.

INTERSTATE EMISSIONS

In 2005, a variant on the cap-and-trade system was introduced to respond to the fact that emissions can also contribute to NAAQS violations in states downwind of the emitting source. Known as the Clean Air Interstate Rule (CAIR), this essentially lowered the SO_2 cap on 27 states and the District of Columbia by 70% by requiring three SO_2 allowances in the place of one. Although finally implemented in 2008, legal proceedings by states and utilities against this legislation have led the EPA to propose the Cross-State Air Pollution Rule (CSAPR) as its replacement. The CSAPR essentially replaces the existing ARP allowances with four separate cap-and-trade programmes covering annual SO_2 and NOx emissions, and summertime NOx emissions which contribute to ozone formation. The 27 states addressed in the CAIR are also split

into two groups with different caps, both of which are more stringent than under the CAIR. After facing a number of legal challenges, the US Court of Appeals for the D.C. Circuit made the decision, in July 2015, to keep the CSAPR in place. A final update was released on 7 September 2016, and the rule eventually came into effect in May 2017.

MERCURY AND AIR TOXICS EMISSIONS

In 2011, the Mercury and Air Toxics Standard (MATS) was introduced to reduce emissions of mercury, other heavy metals, and the acid gases HCl and HF, from new and existing power plants over 25 MW. Under the proposed rule, filterable particulate matter (PM) can be used as a surrogate for the total emissions of non-mercury toxic metals and HCl as a surrogate for both acid gases, while mercury must be measured separately. Existing plants are provided with limits based on both fuel input and energy output, whereas new plants must adhere to output-based limits only. Since the regulation was first proposed, the limits for new plants have been revised. The regulation became effective in 2015. However, since then MATS has faced a series of legal challenges, most recently culminating on 27 December 2018 in a proposed revised Supplemental cost finding for the Mercury and Air Toxics Standards and the Clean Air Act risk and technology review. This review concluded that, having taken into account both the costs to power plants of complying with MATS, and the benefits of regulating hazardous air pollutant (HAP) emissions, the EPA has determined that it is not "appropriate and necessary" to regulate HAP emissions under Section 112 of the Clean Air Act. However, the emission standards and other requirements of the MATS rule, introduced in 2012, remain in place since coal-fired power plants have not been removed from the list of sources that are regulated under Section 112 of the Act. The current emission standards for hazardous air pollutants are given in the following two tables.

Emissions standards for hazardous air pollutants from existing coal-fired power plants

National emission standards for hazardous air pollutants from coal-fired electric utility steam generating units

Plant type	Filterable PM		HCl		Mercury	
	Gross output	Heat input	Gross output	Heat input	Gross output	Heat input
Coal plant	0.3 lb/MWh (136 g/MWh)	0.03 lb/MBtu (47 g/MWh)	0.02 lb/MWh (9.1 g/MWh)	0.002 lb/MBtu (3.1 g/MWh)	0.013 lb/GWh (5.9 g/GWh)	1.2 lb/TBtu (1.9 g/GWh)
Lignite plant	0.3 lb/MWh (136 g/MWh)	0.03 lb/MBtu (47 g/MWh)	0.02 lb/MWh (9.1 g/MWh)	0.002 lb/MBtu (3.1 g/MWh)	0.12 lb/GWh (54 g/GWh) 0.04 lb/GWh[1] (18 g/GWh)	11 lb/TBtu (17 g/GWh) 4 lb/TBtu[1] (6.3 g/GWh)
IGCC	0.4 lb/MWh (181 g/MWh)	0.04 lb/MBtu (63 g/MWh)	0.005 lb/MWh (2.3 g/MWh)	0.0005 lb/MBtu (1.7 g/GWh)	0.03 lb/GWh (14 g/GWh)	2.5 lb/TBtu (3.9 g/GWh)

[1] Beyond-the-floor limit

Emissions standards for hazardous air pollutants from new coal-fired power plants

Reconsideration of certain new source issues: national emission standards for hazardous air pollutants from coal-fired electric utility steam generating units

Plant type	Filterable PM gross output	HCl gross output	Mercury gross output
Coal plant	0.09 lb/MWh (40 g/MWh)	0.01 lb/MWh (4.5 g/MWh)	0.003 lb/GWh (1.3 g/GWh)
Lignite plant	0.09 lb/MWh (40 g/MWh)	0.01 lb/MWh (4.5 g/MWh)	0.04 lb/GWh (18 g/GWh)
IGCC	0.07 lb/MWh (32 g/MWh)	0.002 lb/MWh (0.91 g/MWh)	0.003 lb/GWh (1.3 g/GWh)

Note on conversion to µg/m^3:
Using a basis of coal with 30 GJ/t heat value, producing 350 m^3/GJ flue gas volume (6% oxygen, dry gas at 0°C and 101.3 kPa), 1 g/MWh heat input is equivalent to 0.79 µg/m^3. For a gross efficiency of 35%, 1 g/MWh gross output is equivalent to 0.28 µg/m^3.

CO_2 EMISSIONS

Carbon Pollution Standard

In March 2012, the EPA proposed the Carbon Pollution Standard (CPS) to limit carbon dioxide (CO_2) emissions from new fossil fuel power plants. After a September 2013 revision of the legislation, the EPA gave separate limits for gas and coal plants. On 3 August 2015, the EPA set revised standards (final rule) to limit CO_2 emissions from new, modified and reconstructed power plants (utility boilers and IGCC units). The final emission limits for new sources were based on the performance of highly efficient new coal units implementing a basic version of carbon capture and storage (CCS), that is, one that would require partial capturing of the CO_2 produced in the facility. The limits for modified and reconstructed sources did not require implementation of CCS technology. However, the EPA did not set a standard for units which make small modifications which result in an increase of hourly CO_2 emission of ≤10% when compared to the source's highest hourly emissions in the previous 5 years. Plants implementing larger modifications were included. The limits for new, modified and reconstructed plants are given in the following table.

Carbon pollution standards for utility coal plants

Plant type	Best system of emission reduction	CO_2
New plants	Efficient new supercritical pulverised coal utility boiler implementing partial CCS	1400 lb/MWh gross (635 kg/MWh gross)
Modified plants	Most efficient generation at the affected unit achievable through a combination of best operating practices and equipment upgrades	Sources making modifications resulting in an increase in CO_2 hourly emissions of more than 10% are required to meet a unit-specific emission limit determined best historical annual CO_2 emission rate (from 2002 to the date of the modification); the emission limit will be no more stringent than: 1800 lb/MWh gross (816 kg/MWh gross) for sources with heat input >2000 MBtu/h (>2110 GJ/h) or: 2000 lb/MWh gross (907 kg/MWh gross) for sources with heat input ≤2000 MBtu/h (≤2110 GJ/h)
Reconstructed plants	Most efficient generating technology at the affected source (supercritical steam conditions for the larger, and subcritical conditions for the smaller)	1800 lb/MWh gross (816 kg/MWh gross) for sources with heat input >2000 MBtu/h (>2110 GJ/h) 2000 lb/MWh gross (907 kg/MWh gross) for sources with heat input ≤2000 MBtu/h (≤2110 GJ/h)

Notes:

A new source is any newly constructed coal-fired power plant that commenced construction after 8 January 2014.

A modification is any physical or operational change to an existing source that increases the source's maximum achievable hourly rate of air pollutant emissions. This standard applies to units modified after 18 June 2014.

A reconstructed source is a unit that replaces components to such an extent that the capital cost of the new components exceeds 50% of the capital cost of an entirely new comparable facility. The standard applies to units reconstructed after 18 June 2014.

Clean Power Plan

The Clean Power Plan, proposed in June 2014, was aimed at cutting CO_2 emissions from existing emitters, targeted to achieve a 30% reduction in national CO_2 emissions by 2030 from the 2005 level. Under this

legislation, states would be given specific CO_2 goals and guidelines for the development of emissions reduction plans which could be based on a range of possible strategies, including energy efficiency improvements, investment in renewables, and power plant upgrading. It was left up to the states to develop their own plans to meet their specific CO_2 goal. However, to comply with President Trump's Executive Order on Energy Independence (E.O 13783), signed on 28 March 2017, a review of the Clean Power Plan was held. This led to a proposal being issued on 10 October 2017 for the Clean Power Plan to be repealed, and then on 25 October 2017, the EPA issued an Energy Independence Report to implement Executive Order 13783.

STATE-LEVEL LEGISLATION

Individual states may have stricter emissions standards than those laid out in the national NSPS. For example, in California, Senate Bill 1368 limits long-term investments in baseload generation by the state's utilities to power plants that meet an emissions performance standard (EPS) established by the California Energy Commission in conjunction with the California Public Utilities Commission. The California Energy Commission has established 1100 lb/MWh (499 kg/MWh) of CO_2 as a standard for baseload generation owned by, or under contract to, publicly owned utilities to encourage the development of power plants while minimising their emissions of greenhouse gases.

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